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MANUFACTURING ENGINEERING PROCESSES FOR OFF-ROAD BUGGY'S FUEL TANK PRODUCTION

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ABSTRACT

In automotive industry pre-production design and developing a prototype is major substance to enhance the quality and productivity of the process. There is lot of software packages available to simulate the production plan virtually and analyses the bottlenecks, waiting time, lead time and process outcome without spending more cost and time rather taking make and break decisions. Software simulations are the best way to improve the production plan and design by trial and error.

In this paper, production plan of a fuel tank used for off-road buggy is solely designed and analyzed with value stream mapping, initially the production plan designated to make 200 fuel tanks per week using man power resources and the demand increased to 2000 tanks per week which lead to implement the automation for the process. The production floor is divided based on the process which is to be carried to make the fuel tank that begins with blanking, continuing folding, welding, final welding and inspection. The total KPI for the 200 fuel tanks per tank found out to be 91. 49 minutes due to manual production process and for 2000 tanks per week found to be 17.16 minutes. Activity utilization charts are also included to show the difference in working span in traditional manufacturing process and automated manufacturing. As the manufacturing is flexible cell, the shop floor design was not changed to reduce the investment.

KEYWORDS: Manufacturing Simulation, Simul8, Automotive & Off-Road Vehicle

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Original Article

INTRODUCTION

Background

Design of an automotive production line is very complex and standardizing the particular production line is difficult. It is not feasible to keep on moving the machines in the shop floor for every change we want to implement because this will affect the production rate, repeatability of the machines and more important thing is that it requires lot of investments. As the technology improved, it has led to the possibility for designing the production line. Using simulation software, we can always check for the possibility of varying the lines with introduction of new methods and optimization of the process.

This will help in improvement of the process and quality in every step, which in turn helps in the improvement of the industry. To avoid such problems, many industries have simulation software for process design and improvements.

Simulation is the best tool to understand the production process step by step. For analysis and design of a manufacturing process, simulation is the most widely used technique. Use of simulation software saves both time

and money, which makes it a suitable technique in the design of a production system. Simulation can be used to solve many issues related to the manufacturing industries.

There are many simulation software which are used by the industries in today's market. Some of them are SIMUL8, ARENA, PROMODEL, SIMIO, QUEST. Following are some of the issues which can be solved by the use of simulation software.

- Process and layout design.
- Number of machines required for the process.
- Just in time and bottle neck analysis.
- Inventory management
- Scheduling of the production for a product.
- Evaluation for the change in production volume.
- Effectiveness evaluation of new equipment introduction on a manufacturing system.
- Shipment Timeliness
- Equipment utilization
- Manpower utilization
- Quality control management
- Waiting time analysis

Problem Definition

In this paper, a model of manufacturing line is done to produce parts required for the assembly of 100 buggies per week. For assembling a buggy, it requires many parts like, Chassis, Gearbox, suspension system, Engine, Fuel tank, Transmission unit, Braking system etc. Production of each part requires different manufacturing method and setup. Some of them are Cutting, Machining, Drilling, Welding, folding, assembling and inspection. Different areas of manufacturing have different cycle time, method and assembly to complete the process. So time management between each process has to be taken care.

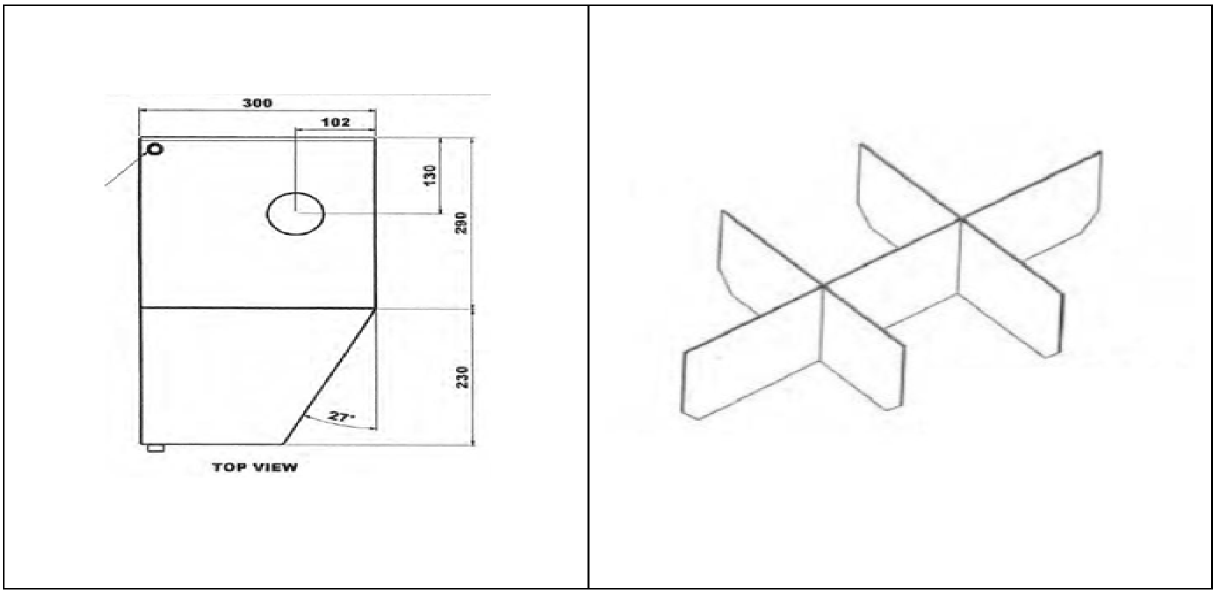


Figure 1: Fuel Tank 2D Design

For this paper, fuel tank manufacturing is been selected. The above figure shows the details of the fuel tank used in buggy.

Mild steel is the material which will be used for the fuel tank. Mild steel has less resistance to corrosion, so it needs a layer of paint to be applied before using it as a material for fuel tank manufacturing. Mild steel is easy to weld, which is an advantage for manufacturing.

Fuel tank consists of two major parts in it namely baffle and filler cap. A hole has to be made on top of the tank to fit the filler cap. Filler cap will be usually made of plastic. On the other hand baffle has to weld to the shape as shown above. Tack welding can be used for baffle. MIG welding can be used for remaining parts of the fuel tank.

Fuel tank will be usually mounted on either sides of the buggy. Here the fuel tank is placed on the buggy and carburetor will be on top of the fuel tank. Pumping the fuel to the carburetor plays an important role here. Considering that two fuel tanks are required for each buggy. This means 200 fuel tanks are required for 100 buggies and 2000 fuel tanks for 1000 buggies.

SIMUL8 software is been selected to simulate the manufacturing process of this particular sub-assembly. The layout is designed for 1 shift each day. The shift timing will be from 8am to 7pm with 5 working days are considered in a week.

SIMUL8

Simulation was invented in the 1960's in the manufacturing sector and simulation software products were originally designed to match the requirements of manufacturers. SIMUL8 was launched in 1994, it was designed from the ground up to match the needs of simulating business processes. It is structured around the flow of transactional work through processes. SIMUL8 is a computer package for Discrete Event Simulation. It allows the user to create a visual model of the system being investigated by drawing objects directly on the screen. Typical objects may be queues or service points.

When the system has been modelled then a simulation can be undertaken. The flow of work items around the system is shown by animation on the screen so that the appropriateness of the model can be assessed. When the structure of the model has been confirmed, then a number of trials can be run and the performance of the system described statistically. Statistics of interest may be average waiting times, utilization of work centers or resources, etc.

SIMUL8 is software for Discrete Event Simulation (DES). In DES, everything is process driven, and every process is independently treated. Since processes are individualized, it is conceivable to have tremendous control over the path in which every process and the related things move through the framework. This control, thus, makes it easy to make extremely exact models.

At the point when the process has been modeled, then a production can be attempted. The stream of work things around the animation is appeared by liveliness on the screen so that the model is suitable or not can be evaluated. At the point when the model's structure has been confirmed, then various trials can be run and the framework's execution is depicted measurably. Measurements of interest may be normal bottle neck process, usage of work focuses or assets.

PRINCIPLES USED IN MANUFACTURING LINES

Lean Manufacturing System

Lean manufacturing is basically based on finding efficiencies and removing wasteful steps that don’t add value to the end product. It is the concept of more value in less work.

Lean Manufacturing adopts the customer value focus in order to achieve more efficiency which in turn results in decreasing the waste. There are some things which as to be followed in order to eliminate waste i.e. like overproduction, waiting, inventory, transportation, over processing, motion, defects and workforce. The lean manufacturing process has the three key stages as follows:

- Identify the waste
- Analyze the waste and find the root cause
- Solve the root cause and repeat the cycle

There are certain tools which are followed such as Like 5s’ philosophy there are other methods which are used to reduce the waste and to attain more efficiency, just like Kanban, zero defects, SMED and Just In Time. At certain times a sixth S used as like a safety.

Flexible Management System (FMS)

A method for producing goods that is readily adaptable to changes in the product being manufactured, in which machines are able to manufacture parts and in the ability to handle varying levels of production. The FMS gives manufacturing firms an advantage in a quickly changing manufacturing environment.

A FMS is a group of numerically-controlled machine tools, interconnected by a central control system. The various machining cells are interconnected, via loading and unloading stations, by an automated transport system. Operational flexibility is enhanced by the ability to execute all manufacturing tasks on numerous product designs in small quantities and with faster delivery. It has been described as an automated job shop and as a miniature automated factory. Simply stated, it is an automated production system that produces one or more families of parts in a flexible manner.

Today, this prospect of automation and flexibility presents the possibility of producing nonstandard parts to create a competitive advantage.

MANUFACTURING PROCESS AND PLANT LAYOUT

Setup for Manufacturing the Fuel Tanks

It is clear that the left and right side tanks have same measurements. The line is symmetrical. Consequently it can be produced utilizing one machine. In the above Figure, the plates are coordinated with the tanks at the welding area.

The steps for manufacturing the fuel tank are as below:

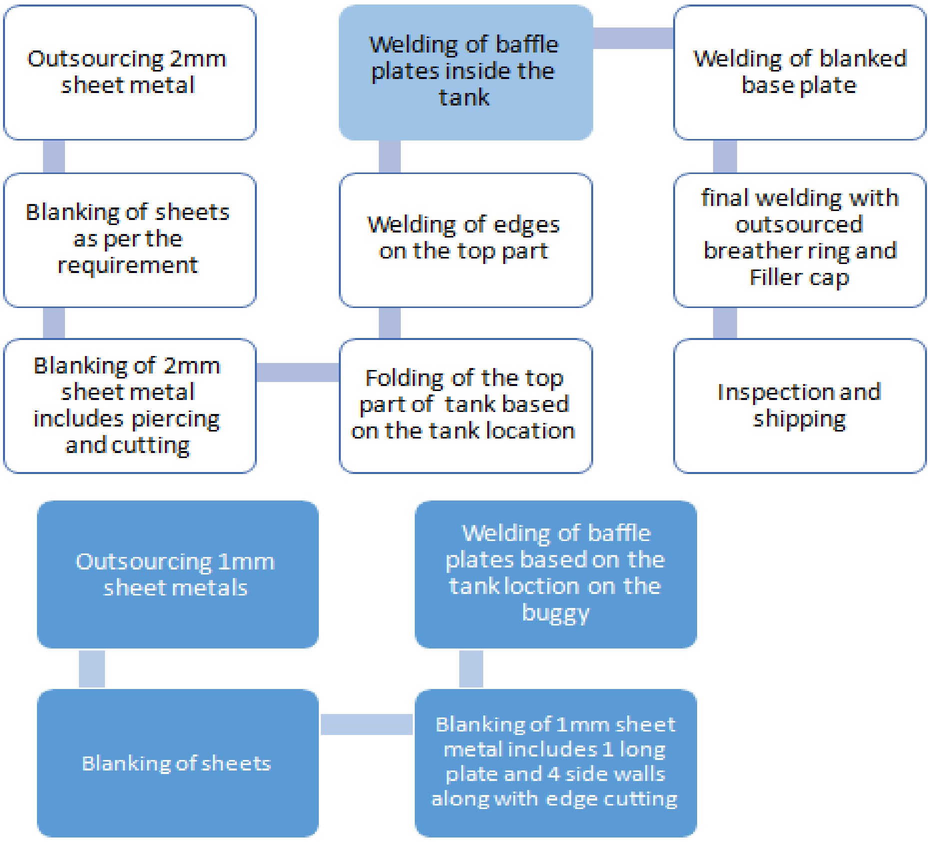


Figure 2: Production Flow of Fuel Tank

- The Mild steel sheets of thicknesses 2mm and 1mm start from beginning point 1, 2 and 3 separately.
- For producing 100 buggies each week, manual cutting can be utilized. For top and bottom parts of the tank, 2mm thickness mild steel sheet will be cut.
- 1mm thickness mild steel sheet will be cut as per the dimensions required for baffle.
- After the cutting operation the sheet required for walls of fuel tank and sheets required for baffles split into two branches.
- Baffle plates are welded as per the design shown in the above figures.
- Plates required for the body of fuel tank are branched into the drilling process, the holes will be drilled for fitting the filler cap, fuel outlet point, breather fitting point.

- The top face and bottom face sheet for fuel tank will be folded in the folding section. The folding of sheets is done along the lines drawn on them.
- Again the sheets are split here for welding. The top face is welded to the side walls, filler cap and breather fitting.
- Then the baffle plates will be attached to the bottom face of the fuel tank by using tack welding.
- At the final work station, the top half and bottom half will be welded together along with breather ring and fill cap, which is outsourced to form a closed container like structure, which is the fuel tank.
- The final stage is the quality inspection. Here all the parameters will be checked and compared with the drawing requirements to ensure the conformance of the product.
- After approval from the quality section, fuel tank will be sent to the dispatch area for shipping.

Simulation of the Process Using Simul8

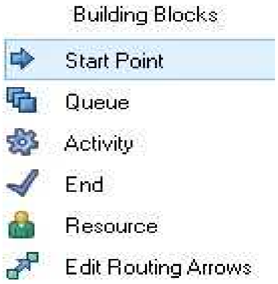


Figure 3: Building Blocks

The above discussed process has been done by using SIMUL8 software.

Start point is the beginning of process where the mild steel sheets arrive. Queue point is the area where finished product is stored for input to the next operation. After queue there will always be an activity. Activity is nothing but the representation of the operation or the machine in the layout.

End block represents that the part has been finished and denotes that the part is ready for shipment. Resource option denotes man power, conveyor and other moving vehicles used in the plant.

For each operation cycle time can be entered. For few operations average value is entered as the time is subjected to vary depending on the operating conditions. For each operation cycle time will be assumed during simulation face.

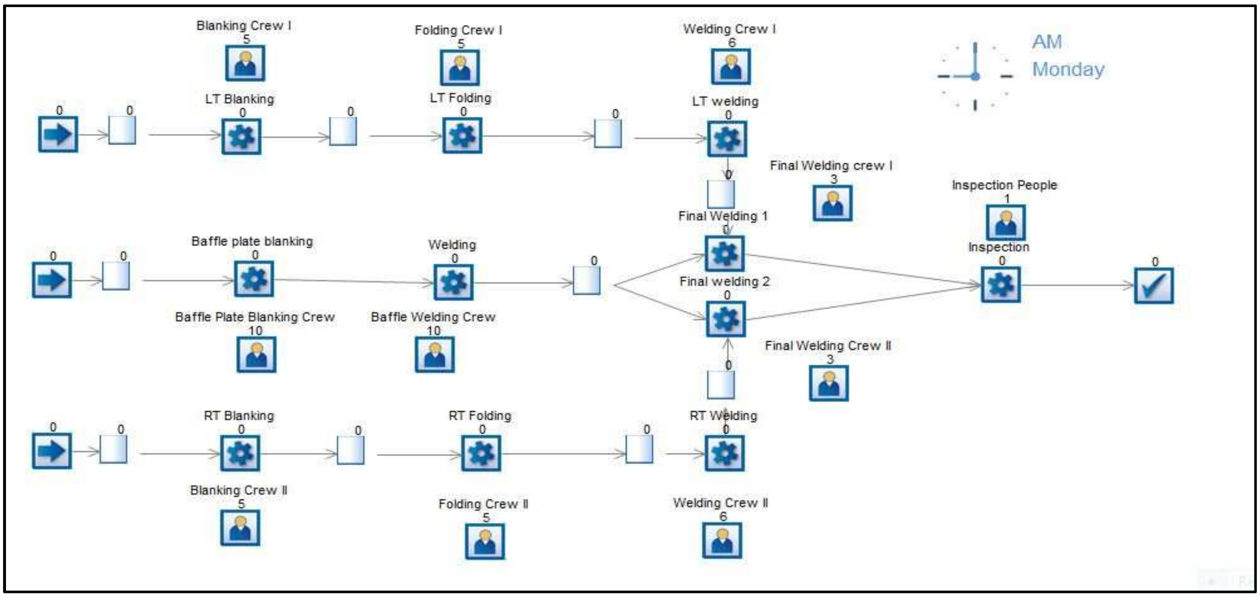


Figure 4: Manufacturing layout

Whenever two inputs converge at single point '*routing in*' is used. It is also known as collect. The operation is performed only when both the inputs arrive that the where it is connected. When the operation diverges, '*routing out*' option is used, Also known as uniform. This option enables the uniform distribution of the components.

SIMULATION RESULTS

Results for 100 Buggies per Week

As the target is less manual methods are used for many operations. For each fuel tank production line, 5 man power is utilized for manual blanking of the sheets (which includes the shape of the sheet with holes) at the first step. Cycle time is assumed to be around 25 minutes. For folding of the metals 20 minutes cycle time is assumed with 5 member in a crew.

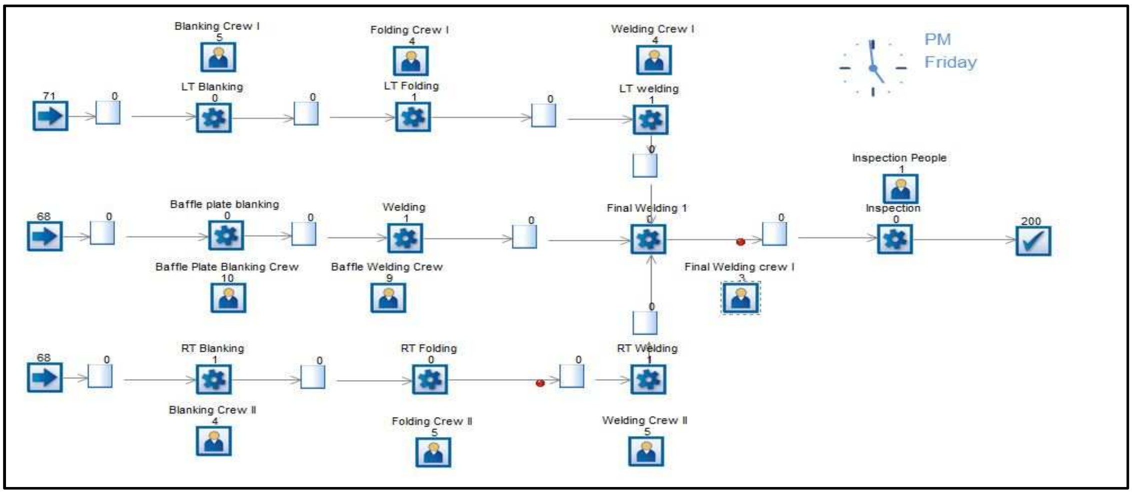


Figure 5: 100 Buggies per Week Plan

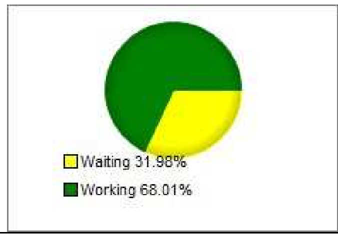
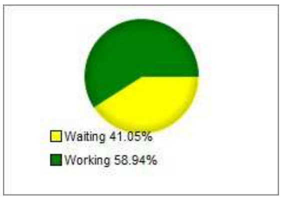
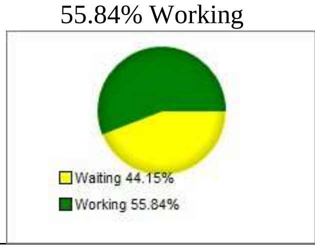
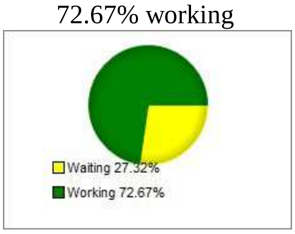
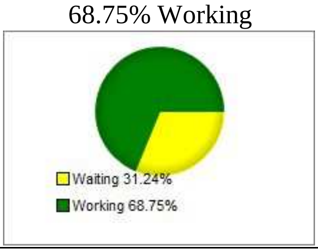
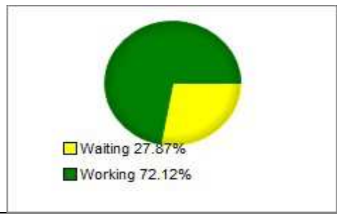
The Welding is of two stages for fuel tanks. In First welding center with the cycle time of 25 min and 6 crew members, edges of the tank is welded and in the finish welding stage with a cycle time of 10 min completes the welding of baffle plates inside the tank with respect to location of tank and the bottom plate is welded together along with breather

ring and filler cap which is outsourced. For baffle plate blanking welding cycle time is 24 and 25 minutes with crew member of 10 respectively. Finally, inspection stage take cycle time of 8 minute by 1 expert person for 100% inspection. The cycle time for each operation is given in the table 1.

Table 1: Cycle Time for 100 Buggies per Week

Process	Left Tank		Right Tank		Baffle Plate	
	Cycle Time (min)	Crew Members	Cycle Time (min)	Crew Members	Cycle Time (min)	Crew Members
Blanking	25	5	25	5	24	10
Folding	20	5	20	5		
Welding	25	6	25	6	25	10
Final Welding	10			3		
Inspection	8			1		

Table 2: Activity Utilization Chart for 100 Buggies per Week

Process	Left Tank	Right Tank	Baffle Plate
Blanking	73.97% Working 	70.23% Working 	68.01% Working 
Folding	58.94% Working 	55.84% Working 	There is no folding operation for baffle plate
Welding	72.67% working 	68.75% Working 	72.12% Working 
Final Welding	 83.76% Working		
Inspection	 66.53% Working		

As from the activity utilization, the waiting period of the process are higher because of the manual operations except for the final welding. The KPI of the system is **91.49 minutes**, which is slower,

Results for 1000 Buggies per Week

In order to produce 1000 buggies per week, Changes has to be made to the process

To achieve the demand, following improvements are to be done.

- Manual cutting should be replaced with machine cutting.
- All the cutting should be made in one machine at the same time.
- Rather than using one drill at a time, all the three drilling operation should be carried out at same time. This can be achieved by designing suitable jigs and fixtures.
- The folding mechanism has to be automated by using a CNC metal folding machine.
- As per the process, welding is considered to be the bottle neck operation. To overcome the queuing in the welding station, the number of welding station has to be increased.
- Cycle time for welding has to be improved.

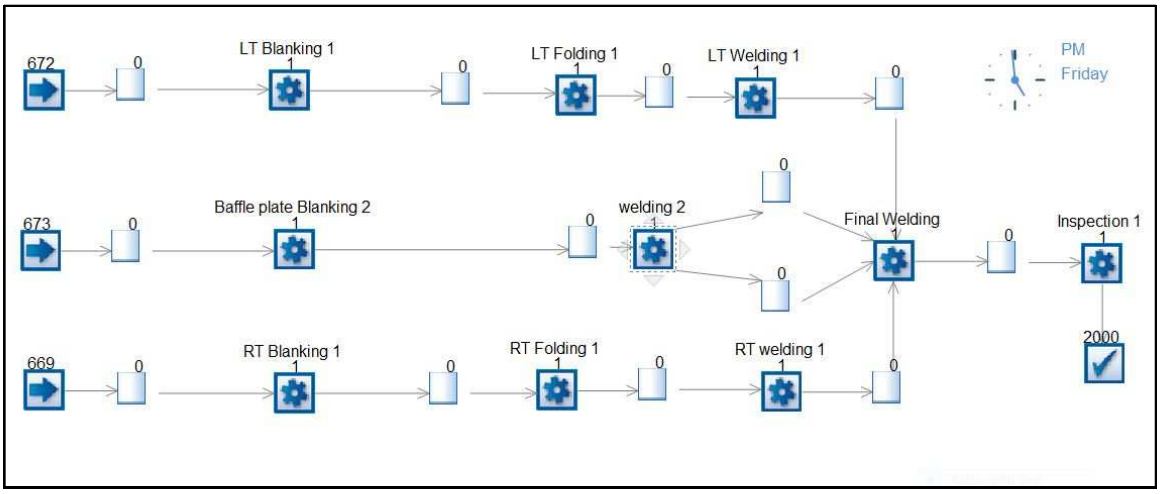


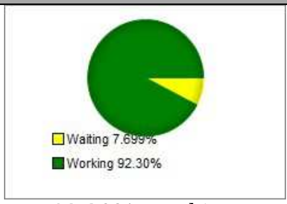
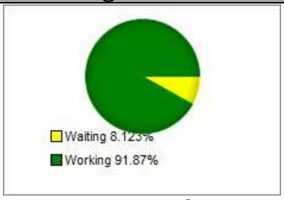
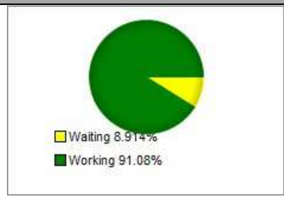
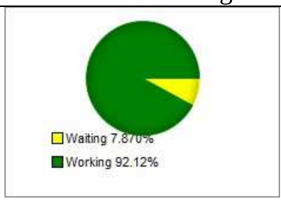
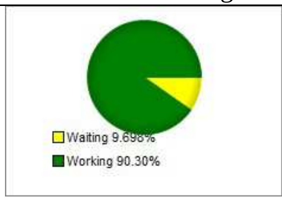
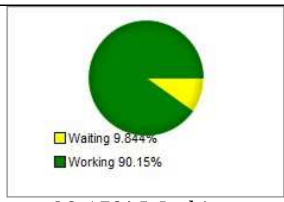
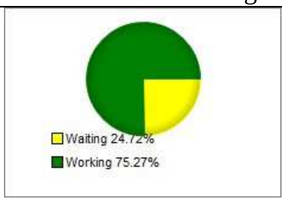
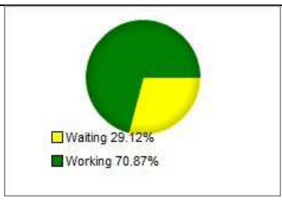
Figure 6: 1000 Buggies per Week Plan

As the demand of the fuel tank got increased to 2000 tanks per week, it became mandatory to increase the delivery frequency of sheet metal and reduce the cycle time of the process by automation. The plant layout wasn't changed, except for the machines. The cycle time for each process is given in the table 3.

Table 3: Cycle Time for 1000 Buggies per Week

Process	Left Tank Cycle Time (min)	Right Tank Cycle Time (min)	Baffle Plate Cycle Time (min)
Blanking	3.3	3.3	3.25
Folding	3.3	3.25	
Welding	3.3	3.3	3.2
Final Welding	0.9		
Inspection	0.85		

Table 4: Activity Utilization Chart for 1000 Buggies per Week

Process	Left Tank	Right Tank	Baffle Plate
Blanking	 92.30% Working	 91.87% Working	 91.08% Working
Folding	 92.12% Working	 90.30% Working	Not Applicable
Welding	 91.97% Working	 91.52% Working	 90.15% Working
Final Welding	 75.27% Working		
Inspection	 70.87% Working		

As the demand rate increased the production rate got increased by reduced cycle time and machine utilization up to the max, the waiting periods represents the down time for maintenance and repair of machines. The KPI of the system is **17.16 minutes**.

Value Stream Mapping for 1000 Buggies per Week

Graphical representation of the steps in a manufacturing process is Value stream mapping. All the information from start to end of the process will be represented in value stream mapping. This will enable the manufacturer to analyze the value adding process also to identify the improvements required for a particular activity. The waiting time for fuel tank is during the mounting.

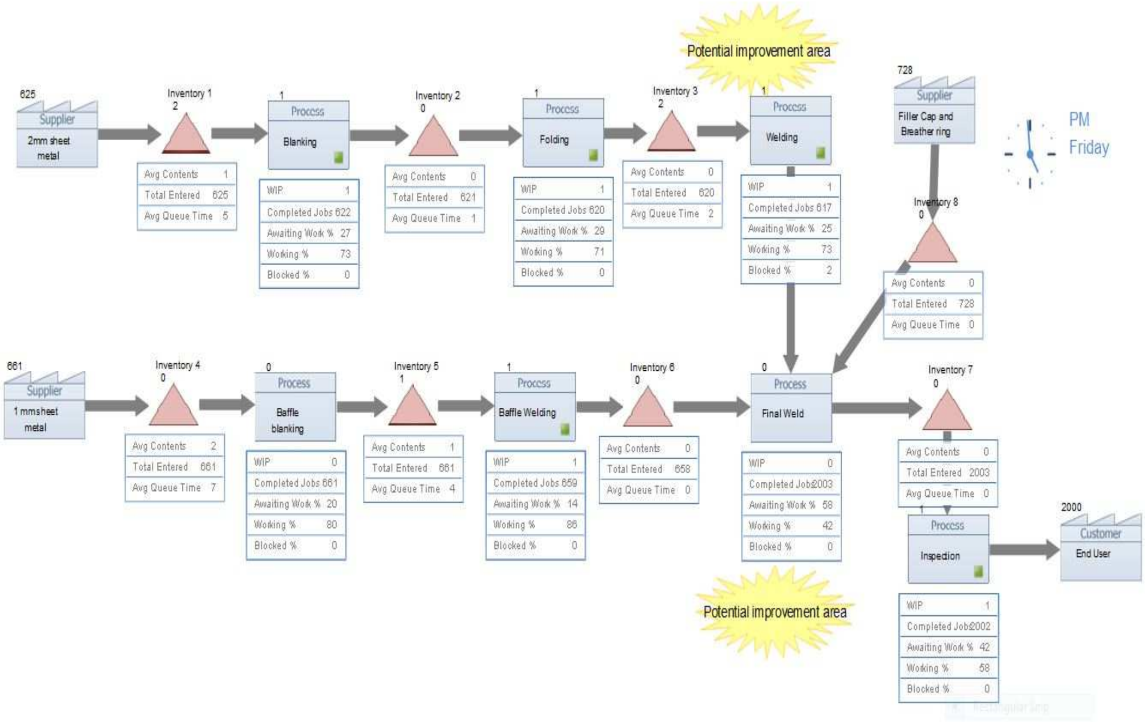


Figure 7: Value Stream Map for 2000 Tanks per Week

When the factory layout is upgraded for the demand of 2000 tanks, few operations has to be automated. This improvement will eventually decrease the cycle time of operation. The non-value adding operation will also be reduced when automation is introduced to the initial production line. To avoid the waiting time and to increase the production rate in the welding process, the man power has to be increased for welding activity. In order to eliminate the waiting time in sources from suppliers and welding section improvements has to be done to the welding process. This calls for a kaizen.

The Key Performance indication (KPI) of the system is **17.57 minute.** The welding process of the system need reformation to reduce the cycle time of the system, which contributes 2% blockage in process.

CONCLUSIONS AND RECOMMENDATIONS

After value stream mapping, it is evident that the welding section needs an improvement both in cycle time and the waiting time. In order to decrease the cycle the time the welding operation has to be automated.

To decrease the waiting time, the number of steps to complete the welding has to be decreased by programming the automated welding machine. Implementation of this will decrease the man power required and also it will decrease the waiting time.

High quality product can be obtained when the welding process is designed properly.

In the plant, all the work stations are overloaded. This indicates that push system production is followed. When the welding process is automated, the pull system of production will come into existence. With this implementation there is a scope for management of the capacity increase.

In this complete analysis of the process, it includes line utilization, cycle time, changeover time. In order to implement the manufacturing line many other factors like production cost, material waste, energy utilization, administration has to be considered.

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